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Product relatedness role on driving industrial policy success

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Abstract

This thesis aims to study how product relatedness to the current pattern of specialization influences the success of industrial policies in underdeveloped sectors. Drawing from Hausmann and Klinger (2006), this work extends the existing literature on the importance of proximity spillovers to explain economic development by focusing on underdeveloped sectors. We find that investment's success in an underdeveloped sector is more likely if it is highly related to the current pattern of specialization. However, heterogeneity amongst sectors is remarkable. Moreover, industrial policy cases are sometimes successful despite the bad odds provided by this criterion, suggesting further factors should be considered.

Keywords: industrial policy; underdeveloped sectors; relatedness; investment success

1. Introduction

Empirical studies suggest that a country's level of income depends on the type of goods it produces (Hausmann, Hwang and Rodrik, 2007). As long as the specialization pattern does not remain constant through time, it is interesting to study what the ability of industrial policy is to improve market outcomes in a world with market failures.

This thesis aims to understand if the success of investments in goods in which the country does not have productive experience depends on how related the goods are to the current specialization pattern, following Hausmann and Klinger (2006), hereafter HK. HK assume that an investment in an unexplored sector is more likely to be well succeeded when the sector is highly related with the sectors in which the country is currently specialized. They suggest that the capabilities and the assets required to produce a given product can be used for other products as well, but the degree of asset specificity depends on how related this sector is to the sectors in which the country is currently specialized (for instance, the assets and the capabilities achieved by producing automobiles are probably more useful for producing tires than for producing apples).

This work also investigates the possibility of reverse causality, in which a less obvious investment can be able to become self-sustainable. That is, while HK assume that, for underdeveloped goods, product relatedness influences the specialization pattern, we propose the hypothesis of the specialization pattern influencing product relatedness. The rationale underlying this approach is that an investment may promote the development of related sectors and producer services, which at their own will help the development of the original sector, making the investment sustainable (Hirschman, 1958). Policy implications are different depending on which of these two versions, or a mix of both, fits reality. While HK's hypothesis suggests that the choice of the sectors to target should be

done mainly in sectors highly related to the ones the country is currently specialized, in order to take opportunity of latent comparative advantages (and amongst those the choice should for instance be based on a comparative analysis of the value each sectors adds), we account for the alternative case in which strong backward and forward linkages can challenge the “natural course”. In case this hypothesis holds, the case for industrial policy would be stronger than in HK’s.

In order to empirically analyze both approaches, i.e. testing the relation between product relatedness and the specialization pattern, two variables were used: Balassa’s (1965) concept of *Revealed Comparative Advantage* (RCA) and Coelho’s (2012) concept of *crude density*. The *density* of a given product is a concept that aims to capture the product’s general degree of relatedness with the goods in which the country is currently specialized, i.e. it intends to apprehend all the spillover effects received by a given product from all the goods in which the country possesses a revealed comparative advantage.

To pursue our inquiry on the influence of (crude) density on the success of an investment in an unexplored sector, two approaches were implemented. The first approach (systematic approach) estimated Granger causality tests on RCA and density (and, in a less extensive way, computed RCA’s “life expectancy”) using aggregate data. This was done on the whole sample (sections 5.1 and 6.1 below, respectively for methodology and results) and on the specific groups that matter the most for this study, namely: i) the group of underdeveloped goods that later became developed (sections 5.2 and 6.2), ii) within the previous group, two subgroups, one covering the goods with a higher density and the other the goods with a lower density (sections 5.3 and 6.3), iii) for each of these two groups, additional divisions on specific sectors and subsectors (sections 5.4 and 6.4). This first method has the merit of gathering the main interactions between product’s

relatedness to the goods in which the country is currently specialized and the evolution of RCA.

The second approach (case-by-case approach) explores the specificities of industrial policy cases that could not be addressed through aggregate data, by using several specific and representative cases of industrial policies, both well and poorly succeeded (sections **5.5** and **6.5**).

This study's main innovations are the focus on underdeveloped sectors and the combination of a systematic and a case-by-case approach. Our results suggest that relatedness with the current pattern of specialization influences positively the likelihood of an investment being well succeeded. Yet, the case-by-case approach suggests that other factors should be taken into account when choosing a sector to target, provided that a substantial part of the industrial policy cases under analysis succeed despite being in low density areas.

The paper is organized as follows: section **2** briefly resumes literature review, section **3** presents the two variables used, section **4** indicates the data sources, section **5** explains the methodological approach, section **6** presents the results, section **7** concludes and section **8** discusses limitations and provides suggestions for further research.

2. Literature Review

There have been numerous debates on the role of the state in market economies. Over time, near-consensus has changed several times. From a strong confidence in free markets' ability to achieve the best outcomes, economists started to distrust the markets' ability to provide proper outcomes, and thus advocated intense government intervention¹.

¹ NY Times. 2014. P. Krugman. <http://www.nytimes.com/2009/09/06/magazine/06Economic-t.html?pagewanted=all>. (accessed at January 6, 2015).

Then, “there came a time when economists started to believe government failure was by far the bigger evil” (Rodrik, 2004: 1), in which we stand nowadays, prompt to the defense that governments should keep hands-off the economy. This section will focus on the debates on the reasons favoring and disfavoring industrial policy.

Before going into the debates, it is important to first define what *industrial policy* is. Although there is no robust consensus, in this thesis, industrial policy refers to selective industrial policy, i.e., a policy favoring some sectors over others. Secondly, it matters to define what *structural transformation* stands for. The definition adopted in this work is the one of HK (2006), who define it as the process of “moving from simple poor-country goods to more complex rich-country goods” (p.1).

In a world with market failures, the specialization patterns obtained through the respect of comparative advantages may not be efficient. Therefore, their presence provides a rationale for industrial policy. These frictions can arise from various sources: i) economies of scale, ii) Marshallian externalities, iii) backward and forward linkages, iv) dynamic economies of scale, v) information spillovers, vi) labor training spillovers, vii) proximity spillovers. A brief summary of each of those will now be presented.

Firstly, we have the broadly known case of scale economies. These arise when, by producing more, the costs of the additional units are lower than those of the previous ones – large fixed costs are the most commonly referred reason imposing this behavior (Rodrik, 2004). Having several firms producing individually at the margin will make total output lower than in the first best equilibrium.

Marshallian externalities (Marshall, 1890) are horizontal externalities arising when a given sector presents agglomeration economies, i.e., decreasing costs as more firms join the market. The most relevant externalities of this kind are labor market pooling,

specialized intermediate input providers and knowledge spillovers. Labor market pooling happens when “a localized industry gains a great advantage from the fact that it offers a constant market for skill” (*ibid*: 271). The availability of specialized intermediate input providers shares the same rationale as the existence of a labor market pooling (Fujita and Thisse, 2013). Finally, knowledge spillovers exist when new ideas are produced “based on the exchange of information and face-to-face communications” (*ibid*: 13).

A third source of market frictions are backward and forward linkages (Hirschman, 1958), which diverge from labor market pooling and specialized intermediate input providers in the sense that they account for vertical externalities². A backward linkage exists when investing in a given sector favors the sectors providing inputs for it, which conversely favor the investment itself. A forward linkage exists when a given investment stimulates investments in sectors using the produced good as an input, increasing its demand.

Fourthly, we have the case of dynamic economies of scale (Krugman, 1987). As firms gain experience in production, they tend to produce more efficiently (learning by doing effect). While an investment may not be profitable in the short-run, it may be profitable in the long-run, as firms gain experience in the field.

These are the more commonly mentioned sources of market frictions. Recently, studies have pointed out alternative sources, from each we will highlight information spillovers, labor training spillovers and proximity spillovers.

According to Hausmann, Hwang and Rodrick (2007), information spillovers are essential to understand the process of structural transformation, as an individual investor faces high uncertainty about the benefits of a given investment. This may prevent innovation from occur. While the benefits of the investment are socialized (i.e., shared with other

² It should be noted that labor market pooling could also be considered a vertical externality.

investors) if it succeeds, if the investment fails only the incumbent faces the loss, causing investments to be sub-optimal if done individually.

The underlying reasoning used for information spillovers is also valid for labor training. As long as labor is mobile, firms will tend to underinvest in training since the investment's benefits may not revert in its totality to the firm (Muehlemann and Wolter, 2006).

Finally, proximity spillovers are usually associated with the benefits of a shared location (Jovanovic, 2003). A less standard definition of “proximity” is proposed by HK (2006), referring to the similarities of characteristics amongst products that make knowledge adaptable from one sector to another one. HK make a metaphor on the product space as being a forest comprising several trees (products), with each monkey (firm) producing in a tree. Growing is achieved through moving from poor parts of the forest (trees providing little fruit) to rich parts of it. While conventional economic theory assumes that monkeys can jump as long as they wish, HK consider that monkeys can only jump to nearby trees. In this sense, the area of the “forest” in which a country has currently its monkeys influences not only current outcomes but also future developments.

All these sources of market frictions imply that decentralized decisions are not able, in general, to achieve the first best equilibrium. In this sense, they may justify government intervention³. While market failures provide a justification for government intervention, many authors contend that they do not provide a sufficient condition: to the extent that government intervention creates other distortions, a positive approach to government intervention would require the net social effect to be positive. These distortions may be derived from the direct cost of intervention (considering that lump-sum transfers do not

³ It should be noted that there are other reasons favoring government intervention besides market failures, although this work will only focus on market failures.

exist) or from failures in government action. Regarding government action, there are several sources of failures.

First, there is no incentive mechanism that encourages policymakers to pursue the general interest, which permits them to act in their own interest. The promotion of “national champions”, for instance, creates space for rent-seeking and corruption: when the aid is seen as no longer desirable, supported firms have incentives to create the artificial idea that they are still in need, thus increasing corrupt behavior of firms and decision makers (Naudé, 2010). Another important source of government failure is the lack of specialized information to choose adequately the sectors to aid and the most effective way of aiding (Pack and Saggi, 2006). Thirdly, the real impact of policies on economic agents and incentive mechanisms is uncertain (Manski, 2010). The inability of a bureaucratic state to act in time is also essential to take into account (Peirce, 1981). Additionally, some (see, for instance, Patrick, 1986) criticize the help to specific sectors on the ground of unjust behavior and asymmetry of treatment⁴.

3. Revealed Comparative Advantage and crude density

The previous section presented the main debates on the characteristics of production patterns that may favor helping some sectors over others and on the potential failures of this favoring scheme. We will focus on analyzing how a sector’s relatedness to the products in which the country is currently specialized influences the success of industrial policies, in the line of HK’s (2006) model of “proximity” spillovers. More precisely, we will test the validity of HK’s assumption that an investment in an unexplored sector is more likely to be well-succeeded when the sector is highly related with the sectors in

⁴ Nevertheless, this discussion should also take into account how leveled the initial playing field is.

which the country is currently specialized. Lastly, we will test the validity of an alternative path, in which a less “obvious” investment is able to become self-sustainable.

3.1. The Balassa Index of RCA

In order to pursue the analysis, we will use a measure for how the specialization pattern for a given good is evolving through time. In this sense, Balassa’s (1965) concept of Revealed Comparative Advantage was used. RCA’s equation goes as follows:

$$RCA_{c,i,t} = \frac{v_{c,i,t} / \sum_i v_{c,i,t}}{\sum_c v_{c,i,t} / \sum_i \sum_c v_{c,i,t}} \quad (1)$$

Where $v_{c,i,t}$ is the value of country c exports of product i at time t ; $\sum_i v_{c,i,t}$ is country’s c total exports at time t ; $\sum_c v_{c,i,t}$ is worldwide total exports of product i at time t ; $\sum_i \sum_c v_{c,i,t}$ is worldwide total exports at time t .

A country is said to have a revealed comparative advantage in a given good if $RCA > 1$, which is why this indicator is usually used as a dummy (1 if $RCA > 1$, 0 otherwise). Since this work analyses a specific characteristic that may drive the success of an investment, the focus will be on the value’s evolution rather than on the value *per se*. If a specific investment enables the country to improve sustainably its relative position in the exports of the good directly concerned by the investment, i.e. if RCA of the concerned good increases consistently above its pre-investment levels, a case is said to have succeeded (even if not surpassing the unity threshold). Otherwise, it has failed.

3.2. Product relatedness

With RCA as our measure for success, we will still need an additional measure, in order to account for product relatedness to the current pattern of specialization. In this sense, we use HK’s (2006) underlying ideas regarding *density*, a concept that has the merit of considering the spillover effects received by each product from all the products in which the country has a revealed comparative advantage without making *a priori* assumptions

regarding the spillovers created by one good over another one. In this sense, it is consistent with a large set of explanations for the process of structural transformation. Freitas et al. (2013) improved HK's method by statistically scrutinizing the results, by allowing relatedness between two goods to be either positive or negative and by permitting non-symmetric impacts, creating a *Revealed Relatedness Index*. Coelho (2012) gave a further improvement in this method, measuring density not by the average spillover effect but by the strength and number of active spillovers. Thus, Coelho's *crude density* method will be used in this work to account for relatedness between products (which, from this point on, will be referred as density). Its formula is:

$$crude\ density_{c,i,t} = \sum_k x_{c,i,t} \varphi_{i,k,t} \quad (2)$$

Where $x_{c,i,t}$ are a country's c revealed comparative advantages in each product i at time t , weighted by $\varphi_{i,k,t}$, the strength of their respective spillover effect towards product i . For details on the construction of $\varphi_{i,k,t}$, see Freitas et al. (2013) and Coelho (2012).

4. Data

The raw data underlying our investigation is Feenstra's et. al. (2005) database, available at NBER, ranging from 1962 to 2000 at 4-digit Standard International Trade Classification (SITC4), Revision 2, with 1070 products from 164 countries. Using a higher level of disaggregation of product categories would narrow both country and time sample and would make it even harder to fit each industrial policy case into some category. Additionally, the databases with more recent data are less complete in terms of either total time sample or country sample, and since this work does not require coverage of a specific time period this is not a concern. In this paper, we use the indicators computed by Coelho (2012).

5. Methodology

The analysis in which this work is based embodies both a systematic and a case-by-case approach.

The systematic approach means to capture the main features concerning the evolution of specialization patterns, by dissecting the relationship between RCAs and densities and their evolution through time. This approach was computed on the whole sample (section 5.1) and on the specific groups that mattered the most for this study. These groups were: i) the group of underdeveloped goods that later managed to have a revealed comparative advantage (section 5.2), ii) within the previous group, two other groups, one covering the goods with “high” density and the other the goods “low” density (section 5.3), iii) for each of these two subgroups, a further division on sectors and subsectors (section 5.4).

Since the systematic approach consists in a macro analysis, it lacks the specific information micro data can give us, which is why a case-by-case analysis of real cases of industrial policy was implemented (section 5.5).

5.1. Systematic approach: overall sample

At first, an overall analysis of causality between RCAs and densities was computed. While HK (2006) pursue the analysis based on the assumption that the relation of RCA and density is unidirectional, this is not clarified on empirical grounds. Thus, in order to understand if data yields general patterns on this, a Granger Causality test was performed. This was implemented using EViews. Provided that we have panel data in our sample, this software treated it as one large stacked set of data, and the only exception relatively to standard Granger Causality tests was not to let data from one cross-section enter the lagged values of data from the next cross-section. This test identifies whether one time series is useful in the forecasting of another one. While being a viable approach to

measure causality, it should be noted that it measures “predictive causality” rather than “causality” itself.

A Granger causality test allows us to test two standard cases (assuming one and only one causal link exists) and find their respective general implications: i) if density causes RCA (HK’s (2006) hypothesis), industrial policy should focus on the sectors having high densities, ii) if RCA causes density (our hypothesis), eventually support could also be directed to sectors in which the country wishes to excel in, even if there are no a priori latent comparative advantages, on the grounds that its support entails a spreading effect across related sectors that allows the investment to be self-sustainable.

The criteria in the number of lags considered in the Granger Causality tests was to use the lower number of lags that gave a significant result for at least one of the two relations, up to a maximum of 5 lags (given that a high number of lags is both unrealistic theoretically and implies the drop of several observations, creating scope for biased results). Results are presented in section 6.1.

5.2. Systematic approach: newly developed sectors

An overall analysis is not able to explain how variables effectively behave and evolve in specific groups. Since this study focuses on understanding which of the unexplored sectors are most likely to provide comparative advantages on a given good, the group of goods that get a revealed comparative advantage while being unexplored (with a “low” RCA) in the beginning (**Group 1**) is our focal group. So, another Granger causality test was computed on the group of goods in which the country is not specialized in the first year of the sample (provided that the RCA was effectively low: a maximum boundary of $RCA=0.25$ was defined) but that later in time achieve a revealed comparative advantage (i.e. obtain $RCA>1$ in at least one year). We are measuring the causality patterns when

considering only the goods that gained the revealed comparative advantage through time. Results are presented in section **6.2**.

5.3. Systematic approach: newly developed sectors with different densities

Departing from **Group 1**, two subgroups, one with “high” (**Group 2**) and the other with “low” (**Group 3**) density were created. That is, the density up to the moment where the country gained a revealed comparative advantage was compared with the densities that other products had and, if “high” (in the fourth quartile of crude densities) or “low” (in the first quartile of crude densities) the observation was added (respectively) to each of the two subgroups. With this grouping division, besides computing a Granger causality test for each subgroup, an additional test was used to check whether or not HK’s (2006) assumption of higher density implying higher RCA fitted the data, since the causality test does not assure us of the sign (positive or negative) of the causality, although intuitively a positive sign is more meaningful. This test consisted in a comparison of RCA’s “life expectancy” for both subgroups, by comparing the number of observations with $RCA > 1$ for both (measuring RCA’s “life expectancy” as long as assuming that the first observation of RCA starts, on average, on the same year for both groups – this is likely to fit reality, because of the large number of the sample’s observations). Results are presented in section **6.3**.

5.4. Systematic approach: newly developed sectors with different densities – specific sectors

An RCA’s “life expectancy” comparison was also computed on specific sectors and subsectors for both **Group 2** and **Group 3**, to test sector homogeneity. This method was chosen over the Granger Causality tests because the latter would imply the drop of several observations due to the use of lags. Results are presented in section **6.4**.

5.5. Case-by-case approach

This set of questions allows an aggregate view of the products with characteristics similar to those targeted by industrial policy (i.e., not possessing a revealed comparative advantage, either with low or high density, either in sector x or y, either in subsector w or z, etc.) and provides some hints for choosing the (sub)sectors to target.

Nevertheless, these hints may be insufficient or even erroneous, as each case has its own specificities that may have been lost in an aggregate data analysis of RCAs and densities.

The risk of having a problem of omitted variable bias is too big to be ignored. Bearing this in mind, a case-by-case analysis was performed.

The analyzed cases were picked based on relevant literature, respecting some requisites, namely the database's timeframe, the fact that the government stopped supporting the industry (avoiding considering a successful case when it is simply the government keeping the industry functioning “artificially” for years) and the dispersion on the globe (aiming to avoid country bias).

Regarding the method used to implement this approach, crude densities for a given product were compared with crude densities of all products for a given year, to obtain their relative position in terms of received spillovers. Through this, we made crude densities, on the one hand, interpretable for a given case and, on the other, comparable with other industrial policy cases. This comparison was made, for each year, both with the goods in which the country did not possess a revealed comparative advantage and with the goods in which it did. The criterion to put each industrial policy case in the subgroup of “high” or “low” densities was to compare the good's densities up to the moment when investment was done with the densities of the products possessing revealed comparative advantage in each of these years. The justification for this lies on the fact

that this study aims to assess how densities influence a country's specialization pattern, and in this way the group for comparison purposes that matters the most is that of the goods possessing a revealed comparative advantage. A threshold of 60% (i.e. being in the top 60% of the products with higher density amongst the goods having a revealed comparative advantage at the year in question, for a considerable number of years) was defined to split the cases. Results are presented in section 6.5.

6. Results

The results of the Granger causality tests are presented in Table 1.

Table 1

	Overall	Group 1	Group 2	Group 3
RCA causing densities: <i>p</i>-value	0.0435	0.7801	2. E-30	0.9998
Crude densities causing RCA: <i>p</i>-value	0.8195	0.1935	2. E-20	0.1657
Number of observations	941610	133266	112086	1042
Number of lags	5	5	2	5

6.1. Systematic approach: overall sample (column “Overall”, Table 1)

The results of the Granger Causality test on the whole sample were surprising, contradicting the most relevant literature on the issue. Indeed, the results favor the hypothesis of RCA causing crude density, while the opposite is not verified. This means that past values of RCA seem to be good forecasters of present values of crude density, while past values of crude density are not good forecasters of RCA.

This is of great importance: indeed, by going against core theory, it provides leeway for implementing industrial policies directly on the most desired sectors⁵, without giving

⁵ These would for instance be the sectors with a higher value added – using for instance Hausmann, Hwang and Rodrik's (2007) concept of PRODY, which gives an associated income/productivity level for each good, and comparing it with their EXPY concept of aggregate PRODY for each country.

indications for the possibility of the direct investment's differenced effectiveness. Thus, the utility of the density concept to explain RCA loses power, and other concepts that explain productive patterns' transformation should be privileged. Yet, a deeper scrutiny of each group and case is demanded: causal links and coefficients will probably depend on the specificities that aggregate data is not able to retain. Industrial policies are useful if they are able to foster success on previously underdeveloped industries and therefore these are the industries in which focus should be placed.

6.2. Systematic approach: newly developed sectors (column “Group 1”, Table 1)

In the group analysis, the first step was to address the causality patterns on the group of goods that get an $RCA > 1$ on the time span of the sample while not having it in the beginning, which is the focal group that will allow us to give advice for future cases of selective policies in underdeveloped sectors (**Group 1**). The results show that, in this sample, no causality link between the two variables is statistically significant. While not useful for advice purposes, this result shows that there are differences at an aggregate and at a group level, meaning that we should take a deeper look.

6.3. Systematic approach: newly developed sectors with different densities (columns “Group 2” and “Group 3”, Table 1)

We proceeded to the analysis of the causality patterns of the two subgroups that are the most important for us: one with the group of goods with “high” density (**Group 2**) and the other with the goods with “low” density (**Group 3**). As one could expect, the results are different in these subsets.

For **Group 2**, the causal linkages go in both ways: RCA causes density and density causes RCA. For **Group 3**, causal links do not exist. So, it seems to be **Group 3** pushing the result on **Group 1**, making causality patterns inexistent there.

While intuitively the effects of densities on RCAs are positive, causal links do not ascertain that. To confirm this intuition, we tested whether or not the RCA was kept for more time in **Group 2** than in **Group 3**. And, indeed, it does: for **Group 2**, 40,9% of observations have an $RCA > 1$; in **Group 3**, only 15,2% do. The p -value of the test of equality between these two proportions is 0, proving that the difference is statistically significant.

Results show that, when a country did not have a revealed comparative advantage on a given good but later got it, the products having higher density were better at keeping it than the ones with lower density, that is, RCA's "life expectancy" is considerably higher for those products with higher density until the moment when they get the first observation with a revealed comparative advantage. This goes along with the traditional theories on the positive role of product relatedness to the current pattern of specialization on the development of RCA. Our results confirm HK's (2006) approach.

6.4. Systematic approach: newly developed sectors with different densities – specific sectors

Differences on RCA's "life expectancy" between "high" and "low" densities were compared for different sectors (that is, they were compared with each subgroup's overall result: 40,9% for **Group 2** and 15,2% for **Group 3**, respectively). The database is divided in 10 main sectors (ranging from 0 to 9, while the 9th sector is for goods not fitting in other categories, and thus was ignored), which were examined. Additionally, we considered each of the subsectors associated with each of the chosen industrial policy cases (presented in the next section). The results are presented in Figure 1 (some subsectors were not included due to the low number of observations), in the Appendices.

No general pattern exists: in fact, for most sectors and subsectors considered, there is no clear advantage of one sector for both **Group 2** and **Group 3** (for example, while the RCA's "life expectancy" in a given sector may be higher for **Group 2** than the inner group's overall "life expectancy" – 40,9% –, for **Group 3** the same sector can have a lower RCA's "life expectancy" than the inner group's overall "life expectancy" – 15,2%). Nonetheless, some facts should be emphasized: i) there are large differences across sectors, ii) food and life animals, crude materials and mineral fuels, lubricants and related materials are sectors with an RCA's "life expectancy" above average, iii) miscellaneous manufactured articles, automobile and mostly footwear have a very low rate of success for products with "low density" while having a high rate of success for products with "high density", iv) batteries seem to be a very hard sector to develop, v) shipbuilding has, surprisingly, a larger "life expectancy" in the "low density" sectors than in the "high density". A comparison with the results on case analysis will be pursued in the next section.

6.5. Case-by-case approach

Finally, a case-by-case approach was implemented. While it is harder to draw generic conclusions from this approach, we can check the nature of the policy more accurately than with aggregate data. A brief summary of each of the 14 identified cases will now be presented, and overall conclusions will be presented afterwards. Cases 1 to 9 were well succeeded; cases 10 to 14 have failed. Graphs for each case are on the Appendices.

6.5.1. Portugal, automobile (graph 1): In 1991, Autoeuropa was created as a joint venture of Ford and Volkswagen and it remains the biggest industrial foreign investment ever in Portugal, with the state's financial support. The factory was finished in 1995.

While Portugal had already received some investments in the automobile area before 1991, the impact of Autoeuropa was huge.

6.5.2. Chile, salmon (Graph 2): The Chilean salmon industry was pushed by the creation, in 1976, of a public venture fund, Fundación Chile, as pointed out by Rodrik (2004). “Fundación Chile played a vital role in importing and transferring technology, thereby triggering the new industry based in the Xth Region (Los Lagos)” (Alvial et al., 2012: 11).

6.5.3. Tunisia, insulated electrical wire and cables (Graph 3): Tunisian’s electrical industry was one of the sectors targeted by import substitution policies during the 1980s, “building on existing production capacities in machinery, tools, and welding”⁶.

6.5.4. Finland, portable phones (Graph 4): Nokia was an industrial conglomerate long before entering the communications sector. “It started its electronics division in the 1960s and subsidised the loss-making subsidiary also for 17 years until the late 1980s when the firm took advantage of the emerging mobile phone market to become a global giant.” (Pourvand, 2013: 23). While privately owned, Nokia received substantial government support in items such as R&D.

6.5.5. South Korea, shipbuilding (Graph 5): In the 1960s, South Korea started a set of policies aimed at promoting a productive shift towards capital-intensive industries. In 1973, a Presidential decree formalized this objective through the Heavy and Chemical Industry Dive that targeted 6 sectors, one of which was shipbuilding. “These were given short-term export targets and official statements were clear that international competitiveness was expected within a brief ten-year period” (Weiss, 2005: 18).

6.5.6. Bangladesh, garment (Graph 6): Up to 1980, garment industries were almost inexistent in Bangladesh. To overcome this, the sector was contemplated by the export-

⁶ The World Bank. 2014. Page 226. http://www.worldbank.org/content/dam/Worldbank/document/MNA/tunisia_report/the_unfinished_revolution_eng_chap7.pdf. (accessed at January 6, 2015)

oriented government policies. In 1980, Noorul Quader's Desh factory produced its first shirts. The factory's owner had an agreement with Daewoo Corporation (South Korean). 130 Quader's workers received training in Korea, in exchange for a percentage of sales value (Quader annulled the contract in 1987, given that production has soared from 43000 shirts in 1980 to 2 million in 1987). Several other firms emerged (a lot of them owned by the trained workers – 115 of the former 130 created new firms) and made Bangladesh a leading country in garment production (Easterly, 2001).

6.5.7. Mauritius, garment (Graph 7): In 1975, Mauritius decided to target garment through the Mauritius Industrial Development Authority and Export Processing Zones Development Authority, which “were created by the government to attract Hong Kong-China's investment in its export processing zone. The vision was to position Mauritius as a world-class export hub on the Hong Kong-China model” (Lin, 2012: 158).

6.5.8. South Africa, automobile (Graph 8): In 1995, the existent local content programs were succeeded, in the automobile sector, by the Motor Industry Development Programme (MIDP), which introduced several export-oriented incentives (Barnes et al., 2003). The most important were the introduction of: i) a mechanism permitting the gain of duty credits from exporting (which allowed to compensate import duties on components), ii) exemptions of 27% of vehicle's wholesale value, iii) exemptions of 20% on investments provided that those aimed at exporting the goods and were product line scale enhancing.

6.5.9. South Africa, wine (Graph 9): The success of the wine industry in South Africa lies on the scrap of the quota system (which favored producing in quantity in spite of quality) in 1992⁷ and, later on, on the incentives given to new planting and replacing on

⁷ Vineyard Varieties. 2014. <http://www.vineyardvarieties.com/history-of-south-african-wine.html>. (accessed at January 6, 2015)

specific varieties (such as shiraz, merlot and chardonnay), with a high value added (Zeng, 2008).

6.5.10. Sweden, shipbuilding (Graph 10): Shipbuilding was one of Sweden's most important industries until the 1970s. However, Japanese competition and the oil crisis of 1973-1975 questioned its viability, making the leading firms incur in huge losses. Thereat, all major firms were nationalized between 1975 and 1978. Shipbuilding and other declining industries (such as steel) received 70-80% of the total state subsidies for the manufacturing industries in the 1970s. Yet, while receiving "the lion's share of industrial subsidies" (Grabas and Nützenadel, 2014), shipbuilding did not survive, formalized by 1984's decision of halting merchant ships production.

6.5.11. Tanzania, footwear (Graph 11): The Morogoro Shoe Factory was one of the top investments in Tanzania, financed by the World Bank (the project was approved in 1977 and the factory was built in the 1970s). The machinery was inadequate for Tanzania's climate and the main problem was the government's inability to competently pursue its initiatives. The factory "never produced more than 4 percent of its installed capacity" and "never exported a single shoe" (Easterly, 2001: 68). Production ceased in 1990.

6.5.12. Jamaica, footwear (Graph 12): Footwear was one of the 7 prioritized sectors by Jamaica's government in the early 1980's based on comparative advantage studies, which favored them. Indeed, the crude density measure also fits this result. However, the policy was not well succeeded (Meditz and Hanratty, 1987).

6.5.13. United Kingdom, semiconductors (Graph 13): Siemens, a German electronics firm, installed a semiconductors factory in Tyneside in 1997, with the British government's financial aid. This "was meant to be the group's leading fab for logic

devices”⁸, but it closed in 1998, with Siemens blaming the sharp drop in demand for computer chips and the concurrence from South-East Asian competitors.

6.5.14. Zambia, batteries (Graph 14): Mansa Batteries opened in 1977, despite a “feasibility study [that] concluded that the project based in Mansa would be uneconomic” (Tangri, 1999: 30). Coughlin and Ikiara (1988) also favor this analysis, suggesting that the investment was carried out to develop the backward region of Luapula province. Our crude density measure does not contradict this idea. The machinery was only a prototype, having never been used elsewhere and not prepared for lasting large periods (Tangri, 1999). The factory finally closed in 1994.

6.5.15. Overall assessment of the case-by-case approach

Summing up, and going along with the analysis of crude densities in the period preceding the investment (illustration provided in **Graphs 1-14**), the 14 cases fit in one of the 4 categories presented in Table 2.

Table 2

	Success	Failure
Low Density	Portugal , automobile Finland , portable phones South Korea , shipbuilding Bangladesh , garment Mauritius , garment South Africa , automobile South Africa , wine	Sweden , shipbuilding Tanzania , footwear United Kingdom , semiconductors Zambia , batteries
High Density	Chile , salmon Tunisia , wire and cables	Jamaica , footwear

The results are mixed: there are cases of both success and failure for both industries with “high” and “low” densities. In this sense, each case should be analyzed at its own, paying attention to its specificities.

⁸ EE Times. 2014. http://www.electronics-eetimes.com/en/bulldozers-finally-demolish-siemens-tynesidefab.html?cm_p_id=7&news_id=212901868. (accessed at January 6, 2015)

Comparing these results with the ones in **Section 6.4.**, the more interesting facts are: i) the automobile industry had, comparatively to the remaining sectors, a very low rate of RCA's "life expectancy" in our aggregate **Group 3** data, nevertheless, the two examples chosen in this sector (Portugal and South Africa) have been, surprisingly, well succeeded, ii) the investment in batteries failed, as one could predict by looking at **Group 3** data, iii) footwear investment in "low" density failed, as "expected" by **Group 3** data, while it also failed in "high" density, contrarily to what one could expect by **Group 2** data.

While the number of cases is not enough to derive general conclusions, the exercise remains interesting. These results suggest that, while assessing general patterns of evolution of RCA and densities can allow more informed choices, industrial policy cases defy probabilities because their success is only partially determined by the right sectors' choice.

Additionally, it must be noted that only 3 out of the 14 cases have targeted "high" density sectors. While this result may derive from unconscious bias in the choice of the cases and/or in the cases that the literature finds most important, this may also mean that governments are more likely to help "low" density sectors.

7. Conclusions

Our results suggest that latent comparative advantages tend to reinforce themselves with the specialization patterns. Yet, this result is general and we have a strong heterogeneity amongst groups. For the underdeveloped goods' group, likely to be the most interesting one to be targeted by industrial policy, the success is larger for sectors in which a latent comparative advantage already exists.

The analysis of industrial policy cases detected a considerable level of heterogeneity, with the cases sometimes contradicting the bad odds the density criterion attributed them. This suggests that there are probably other factors to take into account when pursuing industrial policies that could dictate their success. In this sense, the proposed measure of density must, in our opinion, be seen more as an additional criterion of choice (amongst others, such as the quantity and quality of jobs created, the value added by the sector, the environmental effects) when picking the sectors to target than a mandatory requirement to be fulfilled.

8. Limitations and further research

The most straightforward limitations of this work lie on the implemented measures. RCA has some key limitations: i) it can for instance increase just because the other sectors' exports diminished, ii) internal demand may diverge on its dynamism and exigency from country to country, making production reflex on exports to diverge. Densities' analysis is based on the idea that the relations amongst products are constant through time and space, which may not hold in reality.

Regarding our approach, the time required to make an unexplored sector become a sector with a revealed comparative advantage is disregarded; however, it has deep implications for industrial policy in what concerns costs and on defining the right time to “give up” an investment in a given sector. Additionally, when doing the case-by-case analysis, there might have been a bias towards successful cases that could not reflect reality.

Further research could improve this work by using alternative measures. On the case-by-case approach, gathering data through a more systematic approach (e.g. gathering detailed data on governments' aid by sector) would yield more general results.

An additional research using the mind frame embodied in this study appears to be particularly interesting: a cost-benefit analysis of industrial policies using a systematic approach and accounting not only for the value added but also for effects on employment, environment and inequality, going deeper than the existing studies on industrial policy effectiveness. This thesis could also benefit from incorporating the effect of differences in corruption, political framework and trade openness on industrial policy effectiveness.

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Appendices

Table 3 (output for Granger Causality test on Overall sample: section 6.1)

Pairwise Granger Causality Tests
Sample: 1962 2000
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
CP_INV_PUREDENS does not Granger Cause RCA	941610	0.44190	0.8195
RCA does not Granger Cause CP_INV_PUREDENS		2.28584	0.0435

Table 4 (output for Granger Causality test on Group 1: section 6.2)

Pairwise Granger Causality Tests
Sample: 1962 2000 IF RCA62LOW1=1 AND RCAMAX>1
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
RCA does not Granger Cause CP_INV_PUREDENS	133266	0.49524	0.7801
CP_INV_PUREDENS does not Granger Cause RCA		1.47717	0.1935

Table 5 (output for Granger Causality test on Group 2: section 6.3)

Pairwise Granger Causality Tests
Sample: 1962 2000 IF QUANT1=1 AND RCA62LOW1=1 AND RCAMAX>1
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
CP_INV_PUREDENS does not Granger Cause RCA	112086	45.3457	2.E-20
RCA does not Granger Cause CP_INV_PUREDENS		68.5187	2.E-30

Table 6 (output for Granger Causality test on Group 3: section 6.3)

Pairwise Granger Causality Tests
Sample: 1962 2000 IF QUANT3=1 AND RCA62LOW1=1 AND RCAMAX>1
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Prob.
CP_INV_PUREDENS does not Granger Cause RCA	1042	1.57021	0.1657
RCA does not Granger Cause CP_INV_PUREDENS		0.02020	0.9998

Note on the figure: The dashed spaces correspond to subsectors for which there were too little observations for computation purposes.

Figure 1

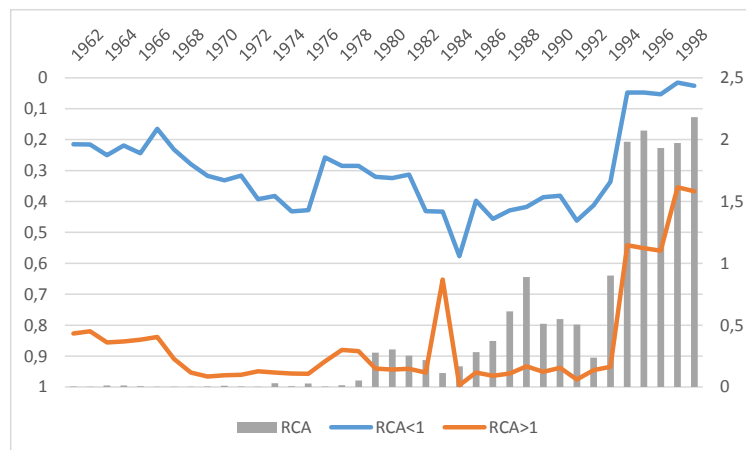
	Low density	High density
Sector 0 - Food and live animals	0,211	0,425
Sector 1 - Beverages and tobacco	0,124	0,369
Sector 2 - Crude materials, inedible, except fuels	0,219	0,405
Sector 3 - Mineral fuels, lubricants and related materials	0,254	0,392
Sector 4 - Animal and vegetable oils, fats and waxes	0,167	0,304
Sector 5 - Chemicals and related products, n.e.s.	0,133	0,358
Sector 6 - Manufactured goods classified chiefly by material	0,118	0,419
Sector 7 - Machinery and transport equipment	0,069	0,371
Sector 8 - Miscellaneous manufactured articles	0,078	0,496
Product 7810 - Automobile	0,05	0,588
Product 371 - Salmon	-	-
Product 7731 - Cables	0,0897	0,357
Product 7641 - Portable phones	-	-
Product 7932 - Shipbuilding	0,182	0,163
Product 8451 - Garment	-	-
Product 8510 - Footwear	0,024	0,765
Product 7763 - Semiconductors	-	-
Product 7781 - Batteries	0,0169	0,349
Overall	0,152	0,409

Comparison relatively to Group's overall	
	Slightly better
	Considerably better
	Slightly worse
	Considerably worse

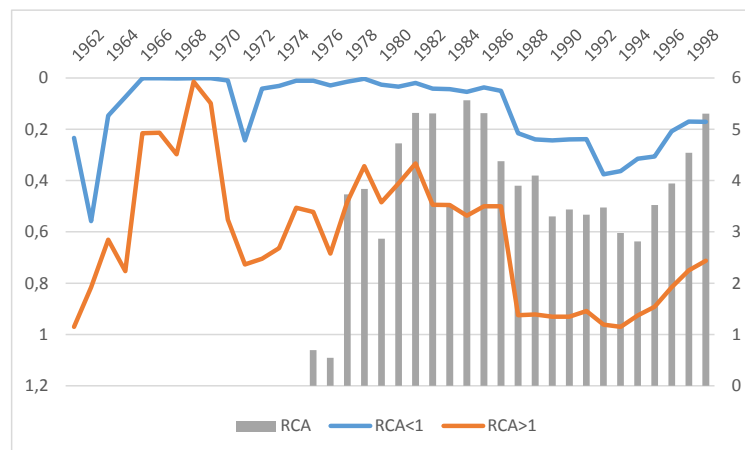
Notes on the graphs:

1. Since on the database used in this work crude densities were inversed, it was decided to inverted the Y-axis (left), since 1 means “very low connectivity” and 0 “very high connectivity” (i.e., the product “receives a lot of spillovers”), so that an improvement is represented by an upward shift in the curve, driving the interpretation more intuitive.
2. The comparison was made both with the group of goods without RCA ($RCA < 1$) and with the group of goods with RCA ($RCA > 1$) (as explained in section 5.5)
3. Left scale is for crude densities comparison, right scale is for RCAs.

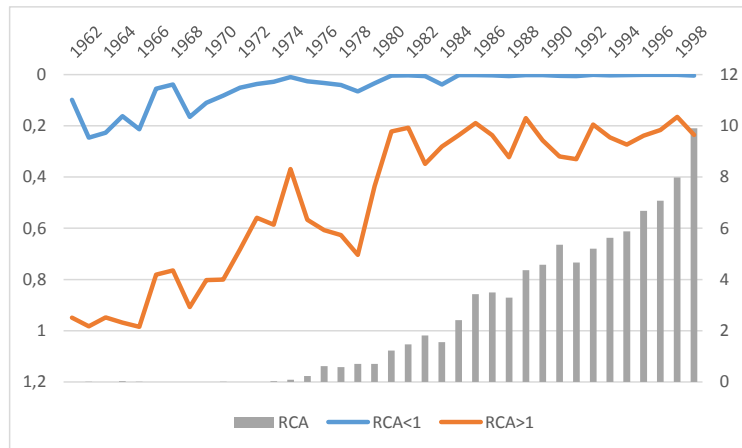
Graph 1 (Portugal, automobile)



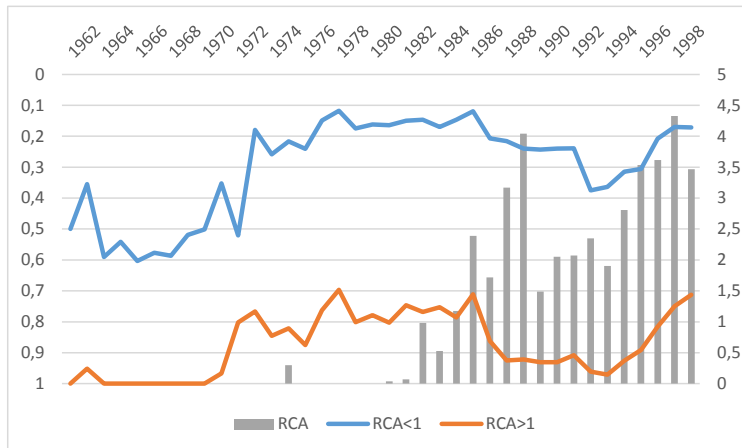
Graph 2 (Chile, salmon)



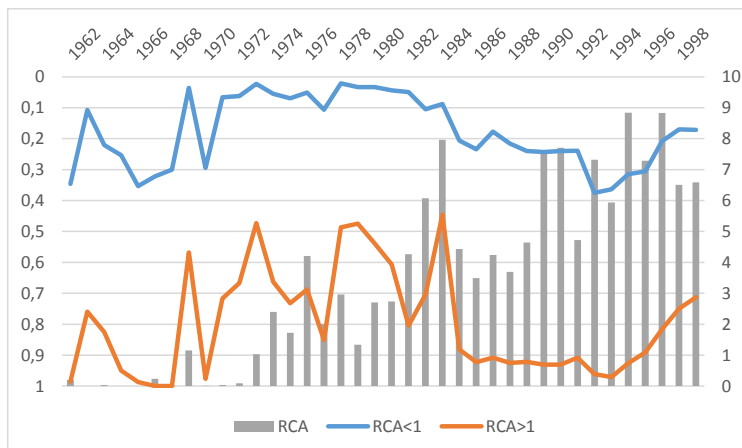
Graph 3 (Tunisia, insulated electrical wires and cables)



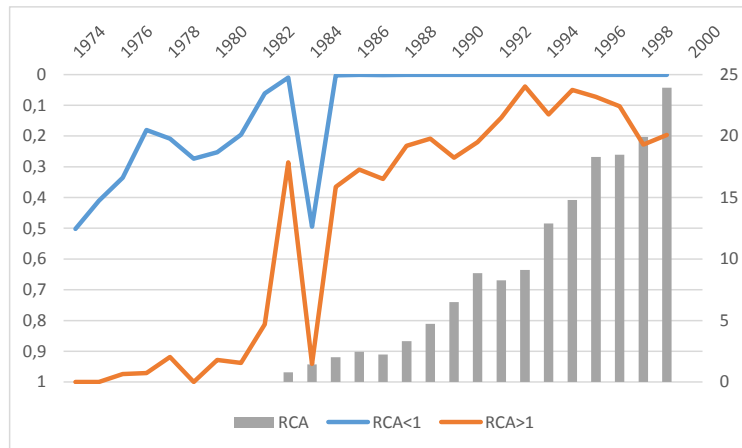
Graph 4 (Finland, portable phones)



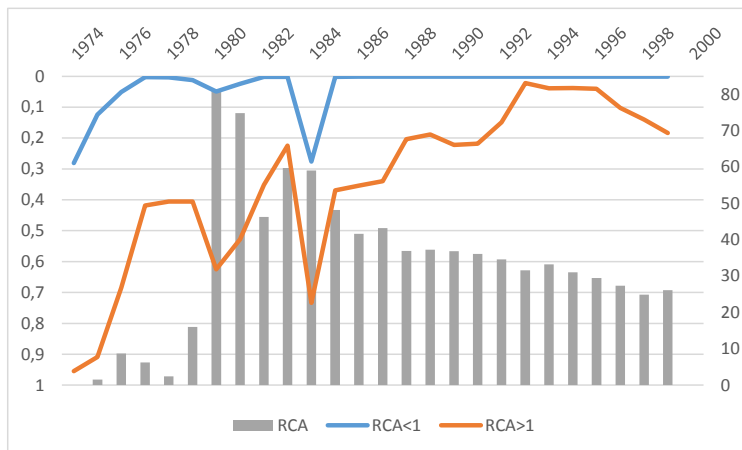
Graph 5 (South Korea, shipbuilding)



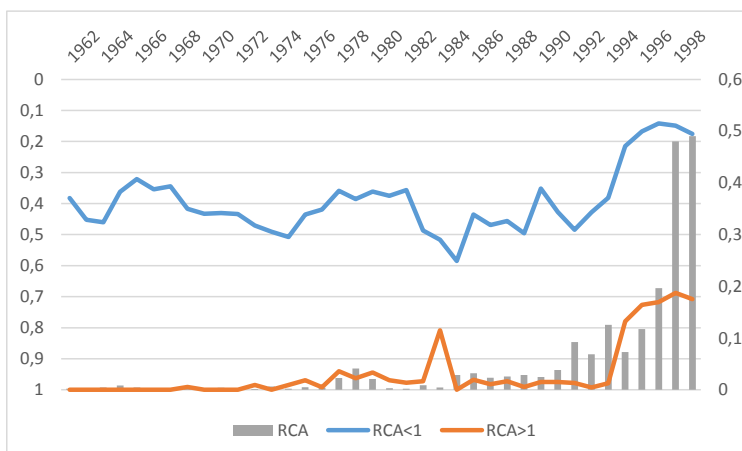
Graph 6 (Bangladesh, garment)



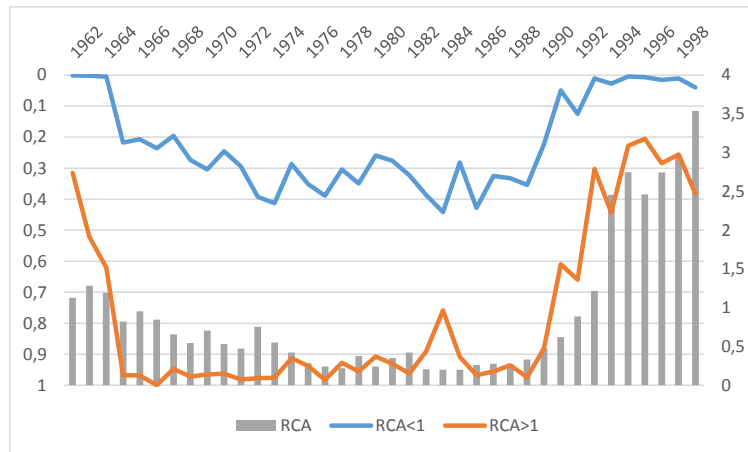
Graph 7 (Mauritius, garment)



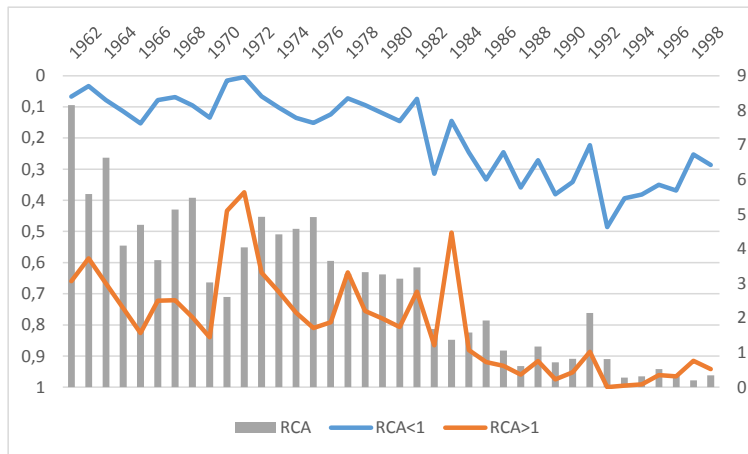
Graph 8 (South Africa, automobile)



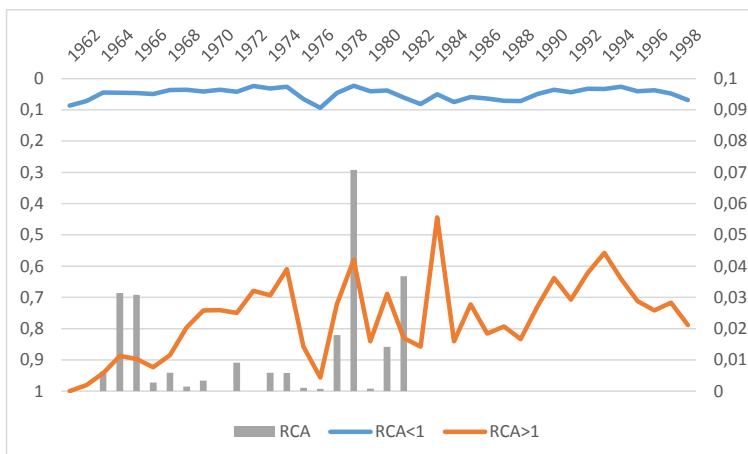
Graph 9 (South Africa, wine)



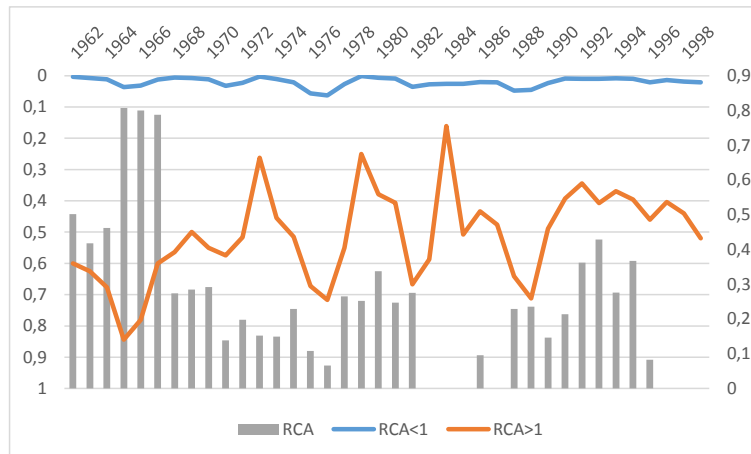
Graph 10 (Sweden, shipbuilding)



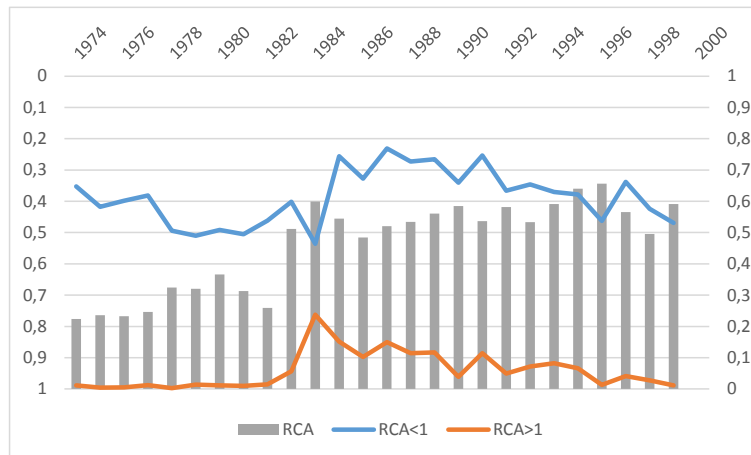
Graph 11 (Tanzania, footwear)



Graph 12 (Jamaica, footwear)



Graph 13 (United Kingdom, semiconductors)



Graph 14 (Zambia, batteries)

